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Proceedings of the Pacific regional peer review on the Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon

June 6-7, 2016
Nanaimo, BC

Chairperson: Mary Thiess
Editors: Shelee Hamilton and Steve Schut

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) meeting that took place June 6-7, 2016 at the Vancouver Island Convention Centre in Nanaimo, B.C. Two working papers focusing on the review and evaluation of fishing-related incidental mortality for Pacific salmon were presented for peer review.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) staff from the Science and Fisheries and Aquaculture Management branches; along with external participants from First Nations organizations, the commercial and recreational fishing sectors, environmental non-governmental organizations, and academia.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to Fisheries Management to inform future processes to derive and/or modify fishing-related incidental mortality estimates for use in the assessment and management of Pacific salmon fisheries.

The Science Advisory Report and two supporting Research Documents will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

Compte rendu de l'examen par les pairs de la région du Pacifique sur l'Examen et évaluation de la mortalité accessoire associé à la pêche pour le saumon du Pacifique

SOMMAIRE

Le présent compte rendu résume les discussions pertinentes et les principales conclusions de la réunion régionale d'examen par des pairs du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada (MPO) qui a eu lieu les 6 et 7 juin 2016, au Vancouver Island Conference Centre de Nanaimo, en Colombie-Britannique. Deux documents de travail portant sur l'examen et l'évaluation de la mortalité accidentelle du saumon du Pacifique liée à la pêche ont été présentés aux fins d'examen par les pairs.

Au nombre des participants en personne ou par conférence Web, il y avait des employés de la Direction des sciences et de la Direction de la gestion des pêches et de l'aquaculture de Pêches et Océans Canada (MPO), ainsi que des représentants d'organisations des Premières Nations, des secteurs de la pêche commerciale et récréative, des organisations non gouvernementales de l'environnement et des universités.

Les conclusions et avis découlant de cet examen seront présentés sous la forme d'un avis scientifique fournissant des conseils à l'intention de la Gestion des pêches, afin d'orienter les futurs processus permettant de calculer ou de modifier les estimations de la mortalité accidentelle liée à la pêche qui serviront à évaluer et à gérer les pêches de saumon du Pacifique.

L'avis scientifique et les deux documents de recherche à l'appui seront rendus publics sur le site Web du calendrier des avis scientifiques du Secrétariat canadien de consultation scientifique (SCCS).

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) meeting was held on June 6-7, 2016 at the Vancouver Island Conference Centre in Nanaimo to review the available literature pertaining to factors relevant to fishing-related incidental mortality (FRIM) of Pacific salmon and to provide recommendations on a process to derive and/or modify current FRIM estimates for use in the assessment and management of Pacific salmon fisheries.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from Fisheries Management. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations, commercial and recreational fishing sectors, environmental non-governmental organizations and academia.

The following working papers (WP) were prepared and made available to meeting participants prior to the meeting (working paper abstracts provided in Appendix B):

1. D. A. Patterson, K. A. Robinson, R.J. Lennox, T. L. Nettles, L. A. Donaldson, E. J. Eliason, G. D. Raby, J. M. Chapman, K. V. Cook, M. R. Donaldson, A. L. Bass, S. M. Drenner, A. J. Reid, S. J. Cooke, S. G. Hinch. Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon. CSAP Working Paper 2014SAL04a.
2. D.A. Patterson, K.A. Robinson, G.D. Raby, A. L. Bass, R. Houtman, S.G. Hinch, S.J. Cooke. Guidance to derive and update fishing-related incidental mortality rates for Pacific salmon. CSAP Working Paper 2014SAL04b.

The meeting Chair, Mary Thiess, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (Science Advisory Report (SAR), Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, working papers, and draft SAR.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteurs for each review. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions into the microphones so they could be heard by those on the phone.

Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 56 people participated in the RPR (Appendix D). Participants were informed that Shelee Hamilton and Steve Schut would be acting as co-rapporteurs for both days of the meeting. Participants were informed that Steve MacDonald (DFO Science), Tony Farrell (Department of Zoology, University of British Columbia, Vancouver, B.C.) and Alex Wertheimer (retired Fisheries Research Biologist, U.S. National Marine Fisheries Service) had been asked before the meeting to provide detailed written reviews for the two working papers to provide starting points for discussion during the RPR. Participants were provided with copies of the written reviews prior to the meeting.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) to Fisheries Management. The SAR and two supporting Research Documents will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

WORKING PAPER 1

Working Paper: Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon D. A. Patterson, K. A. Robinson, R.J. Lennox, T. L. Nettles, L. A. Donaldson, E. J. Eliason,

G. D. Raby, J. M. Chapman, K. V. Cook, M. R. Donaldson, A. L. Bass, S. M. Drenner, A. J. Reid, S. J. Cooke, and S. G. Hinch. CSAP Working Paper 2014SAL04a.

Rapporteurs: Shelee Hamilton and Steve Schut

Presenters: David Patterson, Steve Cooke, Scott Hinch

PRESENTATION OF WORKING PAPER

On behalf of the co-authors, David Patterson, Steve Cooke and Scott Hinch presented an overview of the working paper. The working paper abstract is included in Appendix B. Fishing-related incidental mortality (FRIM) estimates are used by Fisheries Management and Stock Assessment programs to improve estimates of total mortality of Pacific salmon. There are limitations to current methods and information used to generate estimates of different types of FRIM, and therefore Fisheries Management has requested that Science Branch conduct a review of the available literature pertaining to factors relevant to FRIM of Pacific salmon and provide recommendations on a process to derive and/or modify current FRIM estimates for use in the assessment and management of Pacific salmon fisheries. This working paper focused on management's need for improved understanding of the factors related to fish mortality and tools to help distill information on mortality rates, using a fish-centric approach. There are significant challenges with inconsistent use of terminology associated with FRIM throughout the published literature, and the authors tried to clearly define the terms used, use them consistently throughout their work and reference them where possible. Even when estimates are available from individual studies, the limitations of study design make it necessary to interpret the studies that generate them with caution. There is no accepted overall study design, and as such, studies were usually user-group driven and focused on a specific fishery, which can limit the broader applicability of the results. The authors have created an interactive and searchable data repository and evidence catalogue to store and update information on the key factors driving fishing-related incidental mortality and mortality rate estimates currently available in the published literature. This tool was not included in the research document due to its size, but can be provided upon request. The first component of the data repository enables users to better understand how fishing factors that act in consort with extrinsic and intrinsic co-factors elicit different fish responses that can lead to mortality. The second component of the repository compiles published information on fishing-related incidental mortality rate estimates that can be used to quantify mortality risk for particular fisheries.

The authors have conducted a comprehensive review of the relevant primary and grey literature, which included other anadromous salmonids and fishing methods that are not specific to British Columbia to increase the potential of acquiring mortality estimate information associated with species or methods relevant across Canada. They mainly used the Web of Science online database to search for literature, but also used the DFO Waves online database and other sources such as direct requests for information from local fisheries experts and researchers. Factor selection was based in part on the ability to scale factors against a mortality risk, its relevance to drop-off or release mortality, the importance of key interactions, and information on

any issues that may limit the use of the factor in a risk assessment. Factors were selected based on the degree of evidence in the literature, and the utility of the factor as a predictor of mortality. The authors settled on five key factors: capture time, handling, injury, water temperature, and predators. The authors described the five key factors in detail, and then reviewed knowledge gaps. Little is known about the various components of drop-off mortality. It is also difficult to assess the impact of interactions (among and between factors and fisheries). These knowledge gaps result in greater uncertainty.

POINTS OF CLARIFICATION

The authors were asked if the results would be different if they included more sources. They indicated that it likely would not change the key mortality factor results, but additional mortality rate estimates might better inform the scaling and anchoring processes outlined in the second working paper. Reliability can be gauged from the mortality estimate catalogue. The authors indicated they can look at more studies scientifically, but need fisheries experts to assess risk factor scores. The authors requested that participants send any additional information to them for review. Some of the participants mentioned that they did not know how to use the working paper. An author replied that they purposely left out how to use the tool, and that they were leaving it to Fisheries Management and Stock Assessment to decide how to use it. Working Paper 2 might be more useful for Fishery Managers than Working Paper 1.

The authors were asked if they considered the changes in depredation with respect to the dynamic population of seals, or the impacts of different gear types. The authors will review both issues and may expand on them in the Working Paper. They didn't look at downstream mortality due to predators such as lampreys and sea lice since they were tasked to focus specifically on fishing-related mortality.

The authors were asked if they included North Coast data in their review. The authors responded that they had reviewed North Coast data, and that a spatial distribution section will be added to the working paper that describes where the data is from (North Coast versus South Coast) and how it was incorporated.

There was a discussion on quantification of the numeric rates with respect to predators. A participant suggested that numerical criteria would improve consistent application of factor risk scores. The authors were trying to quantify the amount of evidence of predators rather than absolute numbers of predators present, and mentioned that almost all of the scientific evidence was based on depredation. The authors are to add clarity to the paper by providing more information on the quantification of the range of depredation risk score bins. It was also noted that depredation is highly dynamic.

A participant noted that FRIM represents an incremental risk with respect to natural mortality. The Mark Recapture program gives an estimate of natural mortality, but there is uncertainty. The authors suggested they may be able to estimate it; the participant would like this captured in the working paper.

It was debated if there was a need for consistency across jurisdictions, since some values are a point of negotiation. There is not a similar process currently underway in the United States. The Fraser River Assessment Model (FRAM) model has incidental mortality rates for Canadian fish, which are different from what is reported in this working paper. FRAM uses the same numbers from year to year. Although you would expect to find papers with different rates since they considered different variables, it would be good to have consistency. It was noted that the rates should not be expected to remain consistent since fisheries are not consistent over time.

WRITTEN REVIEWS

Alex Wertheimer

- A copy of this review is included in Appendix E. The reviewer was unable to participate in the RPR so his review was presented by the Chair on his behalf.
- Individual factor scores get lost in the combined FRIM risk score for a given fishery. The dominance score may be masking others. The reviewer would like to see more discussion, including examples, on the ranges of mortality estimates. Authors will include the range of mortality estimates in an appendix of Working Paper 1, including a comment or information on the sensitivity of estimates to the range of uncertainty in encounter rates. The reviewer suggested it would also be useful to include more information on effort and encounter rates. The reviewer asked for clarification on how to translate encounter rates with respect to probability of encountering a stock of concern. An author suggested that interpretation is covered in Working Paper 2.

Tony Farrell

- A copy of this review is included in Appendix E. As a virtual participant (participating by phone and webinar), the reviewer did not make a formal presentation of his review. A summary of his main points for discussion was posted on-screen for participants to consider and discuss. Many concerns raised in his review were addressed during the authors' presentation of the working paper.

WORKING PAPER 2

Working Paper: Guidance to derive and update fishing-related incidental mortality rates for Pacific salmon. D.A. Patterson, K.A. Robinson, G.D. Raby, A. L. Bass, R. Houtman, S.G. Hinch, and S.J. Cooke. CSAP Working Paper 2014-SAL04b.

Rapporteurs: Shelee Hamilton and Steve Schut

Presenter(s): David Patterson

PRESENTATION OF WORKING PAPER

On behalf of the co-authors, David Patterson presented an overview of the working paper. The working paper abstract is included in Appendix B. This paper provides guidance towards deriving and updating estimates of fishing-related incidental mortality (FRIM) for Pacific salmon (*Oncorhynchus* spp.) captured in salmon-directed fisheries, based on the five key factors identified in Working Paper 1 (capture time, handling (air exposure and handling time), injury, water temperature, and predators). It was noted that no current framework to evaluate or update FRIM estimates exists. This paper presents an initial attempt at developing such a framework, but should not be considered a final result. The authors tried to match the existing science information with the many applications that it can and will be used to inform. In many cases, there was limited information, and they were looking at the mortality of fish not intended for retention. There were seven mortality categories (avoidance, escape, depredation, drop-out, on-board, short-term post-release, and delayed post-release mortality). The purpose was not to generate estimates but to test the validation method to ensure the factors could actually predict published FRIM rates with some degree of reliability. The overall relevance of the proposed anchoring method needs to be assessed by experts (not the authors) as they are not familiar with the details of individual fisheries. The authors' conclusions were based on the five key factors. They do not recommend finer separation of non-capture mortality into its components because developing reliable estimates based on fisher recall seems untenable at this time. This

working paper presents the initial steps in a process, not a prescriptive tool. The results can also be used to identify opportunities to mitigate risk, and needs to be part of a broader risk assessment plan.

POINTS OF CLARIFICATION

There was a discussion on the definition of non-capture mortality. It is expressed as a proportion of total landings, and is fishery dependent. It was noted that the risk of water-line releases would be handling time and not air exposure, and this needs to be considered by the scorer as it could have a large impact on the score. There is an educational opportunity with respect to the handling category as it may be the easiest to mitigate in fisheries.

Some participants wanted the Working Paper to include an example of the proposed anchoring method. They also asked the authors to use actual data (as opposed to experimental data) to show how the process works. An outline of the process that could go into the Working Paper and the Science Advisory Report was suggested. The authors agreed to flip the axes of the figure illustrating the explanatory power of the combined risk scores, add confidence intervals and provide an example for the second day of the meeting. It was noted that there is a risk assessment tool under the Catch Monitoring Framework that may be helpful. Participants agreed to send a copy to the authors for their review and suggested they try to align as much as possible with the terminology used in that document. The authors will re-consider if the mortality risk should be defined as a percentage or a scale.

WRITTEN REVIEW

Steve MacDonald

- A copy of this review is included in Appendix E. The reviewer was available at the meeting and presented an overview of his comments.
- The Working Paper describes a process, not a prescription. Figure 2 describes the problem well. You can develop FRIM estimates for each fishery with information from Fisheries Managers, but it seems to be developing a risk model and not incidental mortality rates. Experts can fill in the data gaps.
- Figure 4 may be misinterpreted as lacking evidence of validation; could reverse engineer a modelling approach if we had one. This figure needs to be reviewed because it is misleading. There is a need for clarity on how anchoring is concluded, and how the process is undertaken.
- It is not necessarily advantageous for Science to have one non-capture mortality rate, although it might be useful for Fisheries Managers. The authors agreed to provide a better description of the factor scoring process.

GENERAL DISCUSSION

The Chair reviewed the objectives from the Terms of Reference and invited participants to share questions and comments with respect to each of the objectives, and then guided the decision on whether to accept or reject each paper.

WORKING PAPER 1

Objective 1: *Identify and discuss potential impacts of key factors that can influence fishing-related incidental mortality for Pacific salmon.*

The general consensus was that the working paper dealt with this satisfactorily. There

was a comment that predators were not adequately addressed, but the information is also not available in the scientific literature. The issue was highlighted as a research gap and will be a recommendation in the Science Advisory Report.

Objective 2: *Conduct a comprehensive review of the primary and grey literature that contains documented evidence (e.g. mortality rates) of fishing-related incidental mortality for anadromous salmonids.*

Initial concerns were addressed once the authors explained that all files containing the sources of data are available upon request. There was discussion about the potential added value of including additional grey literature sources in the data repository (given that, in some cases, it is more difficult to objectively assess grey literature using the same criteria as peer-reviewed publications). In the end, the authors agreed to add grey literature containing mortality rate estimates from WAVES (the online repository of DFO publications) to the data repository tool during revisions to the research document. The authors will also look closer into spatial biases between available North Coast and South Coast mortality data. Differences may be shown through gear and fishery characteristics, but may not change the results as they are now. There may also be stock-specific mortality rates, and therefore stock-specific research will be added as a recommendation. It was decided that improved resolution for the anchoring process will result from including more grey literature.

Objective 3: *Identify uncertainties and knowledge gaps in the information that is currently available to inform estimates of fishing-related incidental mortality for Pacific salmon.*

Publication bias was discussed in Working Paper 1, including a noted lack of comparative studies on Pacific salmon to draw strong conclusions from. There was consensus among participants that this objective had been sufficiently addressed.

Revisions for Working Paper 1

Terminology and text clarity will be reviewed; the glossary will be moved up in the document. The rationale of the risk factor scoring tables will be improved, as well as the overall flow of the document. The authors will update the tables to include additional grey literature, and compare the grey and primary literature to see if there is a publication bias. A spatial distribution section will be added that describes where the data is from (North Coast versus South Coast) and how it was incorporated.

WORKING PAPER 2

Objective 4: *Provide guidance with respect to a process to derive (or update existing) fishing-related incidental mortality rates (or range of rates) for Pacific salmon by species, gear type, location, and/or other factors deemed relevant to various fisheries (where possible and appropriate).*

The Working Paper does outline a process, and provides risk factor tables that can be used to assess fisheries. The risk scores should be consistent, but the proposed anchoring method needs input from and testing by experts with knowledge of the fisheries. Science staff will be using these Working Papers to generate estimates of FRIM for specific stocks and fisheries in the near future, and will help determine if the guidance works as outlined. There was much discussion among participants about the acceptability of the proposed method given that it had not yet been tested. The authors emphasized that their work provides a starting point and that the working paper identifies it needs to form part of a larger risk assessment plan.

Objective 5: *Provide guidance with respect to the future incorporation of new information and research on fishing-related incidental mortality of Pacific salmon.*

The Working Paper described how to incorporate new information, but not who would do it. There needs to be a mix of Fisheries Management and Science staff assigned to this issue. Longer term studies are needed to fill in the research gaps. There are two CSAS processes coming up that will involve Science, Fisheries Management, First Nations and others to attempt to apply the tools presented here to specific fisheries and stocks. It was suggested to add a recommendation for Fisheries Management to make a request to Science to explain how they can apply these Working Papers to fisheries in the North and South Coast, and compare it to the values currently in the Integrated Fisheries Management Plans.

The authors agreed to clearly identify an example of the process so that Fisheries Managers can follow it. There were some factors that overrode others. The authors will also re-word the section outlining factor interactions in the Working Paper, and specify that results from hydro-acoustic studies were not included in this paper.

Revisions for Working Paper 2

Figure 4: Flip axes so that Mortality Risk Score is on the x-axis and Observed Mortality Estimate is on the y-axis. Ensure the x-axis scale goes from 0-100%.

The authors will update Working Paper 2 with a figure (or table) that better describes the process of combining the individual mortality risk factor scores into a single risk score. They will also review the Catch Monitoring Risk Assessment Framework to see if it is possible to better align the terminology used in each process. The authors will look into including a section on assessing likelihood (encounter rates) and consequences (severity of impact).

There was consensus among participants that both working papers will be accepted pending agreed upon revisions to be made by the authors.

The group spent the remainder of the scheduled meeting time reviewing and editing the wording of the draft Science Advisory Report (SAR).

CONCLUSIONS & ADVICE

- Both working papers were accepted pending agreed upon revisions to be made by the authors.
- This work provides a robust and transparent method for assessing the relative risk of FRIM across Pacific salmon fisheries.
- This type of mechanistic assessment (i.e. with a primary focus on fish response) to describe FRIM provides opportunities to highlight and prioritize areas to mitigate FRIM risks. For example, if actions to reduce air exposure are proposed in fisheries where the present relative risk is found to be high, handling requirements that reduce air exposure could lead to direct reductions in FRIM risks.
- Accurate, objective estimates of FRIM rates are inherently difficult to obtain. Even when such estimates are available from individual studies, the limitations of study design make it necessary to interpret the studies that generate them with caution and require informed consideration of the context-specificity and possible biases associated with them.
- Very little published research currently exists to allow for quantification of drop-off mortality rates.

- The total impacts of FRIM are under-estimated by the use of short-term mortality assessments (i.e. mortality assessed within 24 hours of the interaction with a fishery). Where possible, use of longer-term mortality estimates is recommended.
- Continued monitoring and research of the five key factors (e.g. water temperature, air exposure) and how they interact is recommended. Given that water temperatures are dynamic and are expected to continue to rise with climate change, additional research related to water temperature and the mechanisms underlying incidental mortality is a high priority. For example, the importance of understanding the interaction between water temperature and injury will be relevant for both pre-season planning and post-season accounting.
- Additional research and monitoring of fishery-specific factors are recommended to improve the information base available to characterize FRIM for certain fisheries (e.g. census information on injuries, handling practices). The inability to accurately describe the conditions of realistic fisheries limits the utility of risk assessment approaches for stock assessment and fishery management purposes.
- This project demonstrates in principle the utility of the risk assessment tool. More work and feedback is required before the proposed risk assessment tool can be applied for certain uses in management (e.g. to update Integrated Fisheries Management Plan tables). Recommended next steps include engaging in discussion with a wider audience and incorporating monitoring and reporting systems to provide information.
- A proposed anchoring method was outlined to link relative FRIM risk scores to absolute mortality rate estimates. Further work is recommended to test and refine the method prior to broader application; a case study on the potential utility of the method for translating relative FRIM risk into actual FRIM rates is scheduled for further CSAP review, Fall 2016.
- There are multiple uses of FRIM in fisheries management and stock assessment that vary in application across different fisheries. This variability results in a multitude of additional information requirements that need to be addressed before model outputs that require FRIM can be calculated. These information requirements can include estimates of stock-age composition, encounter rates, fleet profiles, and compliance rates.
- There is inconsistent use of various terms throughout the published and grey literature. The interpretation of variable definitions and categorizations of fishing factor details and mortality outcomes is difficult (e.g. different sectors have developed and use similar terms in very different ways, and very different terms in similar ways). In the future, adopting a standardized set of terminology will aid in the direct comparability of future research efforts and possibly allow for the disaggregation of some FRIM components leading to further improvements in the accuracy of FRIM estimates.
- Owing to similarities in their content and approach, and in order to provide departmental consistency, it is recommended that future work related to FRIM and the recently-developed Catch Monitoring Risk Assessment Framework (terminology and methods) be aligned and linked, wherever possible.
- Continued development and validation of vitality indices (i.e. surrogate assessment tools that can be used to reliably predict release mortality) along with a rapid injury assessment tool to predict FRIM in the field could assist in the ability to generalize and streamline the process to assess FRIM risks for release mortality.
- As new information becomes available (with respect to both emerging research and changing fisheries practices), it will be necessary to update the factor analysis, mortality evidence catalogue, factor scoring, and risk assessment tool accordingly. The evidence

catalogue, which was used to inform the key factors that affect FRIM, has been designed so that it can be updated and reviewed as new findings from salmon and other species become available.

ACKNOWLEDGEMENTS

The Chair thanks the authors for producing valuable research documents under challenging timelines; the project team for their contributions during the review and process development stages; Tony Farrell, Alex Wertheimer and Steve Macdonald for their conscientious written reviews; the RPR participants for their constructive input during the meeting; Shelee Hamilton and Steve Schut for their work as rapporteurs, both at the meeting and to produce these proceedings; and finally, the CSAS office (Lesley MacDougall, Ann Mariscak and Linnea Flostrand) for their assistance in coordinating the meeting and producing the final reports.

APPENDIX A: TERMS OF REFERENCE

Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon

Regional Peer Review Process – Pacific Region

June 6-7, 2016
Nanaimo, BC

Chairperson: Mary Thiess

Context

Stock assessment methods for Pacific salmon require estimates of total mortality in order to obtain accurate exploitation rate and stock size estimates. Total mortality includes natural and fishing-related causes. The latter is composed of retained catch, plus any incidental mortalities associated with fishing activities. Fishing-related incidental mortality can be accounted for by assessing mortality prior to harvest (e.g. depredated and escaped fish), mortality at time of harvest (i.e. fish—other than retained catch—that are dead upon capture), and mortality post-release (i.e. non-retained fish).

Several issues have been raised with respect to the information currently used to generate estimates of different types of fishing-related incidental mortality, including the variability in the time course to monitor mortality after a fishing encounter, the lack of fishery context-specific information (e.g. water temperature), and the need for an efficient process to incorporate new research as it becomes available. For example, recent research indicates that longer-term (i.e. greater than 24 hours) post-release mortality rates are higher than those currently documented in the Integrated Fisheries Management Plans (IFMPs) based mainly on 24-hour holding studies that were conducted prior to 2001 (Raby et al. 2015). Similarly, recent studies relevant to other aspects of fishing-related incidental mortality have not been incorporated into current estimates of mortality used by DFO Fisheries Management and Stock Assessment.

Improved estimates of fishing-related incidental mortality will reduce the uncertainty in predicting the impacts of different fisheries. An improved understanding of factors that impact fishing-related incidental mortality estimates will aid in post-season accounting of both natural and fishing-related mortality. In addition, the evaluation of all types of non-retention related mortality will improve Canada's commitment to quantify total mortality in the Pacific Salmon Treaty.

Fisheries Management has requested that Science Branch conduct a review of the available literature pertaining to factors relevant to fishing-related incidental mortality of Pacific salmon and provide recommendations on a process to derive and/or modify current estimates of fisheries-related incidental mortality rates for use in the assessment and management of Pacific salmon fisheries.

Advice arising from this CSAS Regional Peer Review (RPR) process will be provided to Fisheries Management in the form of a Science Advisory Report for their consideration in managing Pacific salmon fisheries, and to Stock Assessment for application in relevant Pacific salmon stock assessments. The recommendations may also be relevant to work conducted by the Pacific Salmon Commission Technical Committees.

Objectives

The following working papers will be reviewed, and provide the basis for discussion and advice on the specific objectives outlined below:

Part A.

Patterson, D. *et al.* Review and evaluation of fishing-related incidental mortality for Pacific salmon. *CSAP Working Paper 2014SAL04a.*

1. Identify and discuss potential impacts of key factors that can influence fishing-related incidental mortality for Pacific salmon.
2. Conduct a comprehensive review of the primary and grey literature that contains documented evidence (e.g. mortality rates) of fishing-related incidental mortality for anadromous salmonids.
3. Identify uncertainties and knowledge gaps in the information that is currently available to inform estimates of fishing-related incidental mortality for Pacific salmon.

Part B.

Patterson, D. *et al.* Case study: A process to derive fishing-related incidental mortality rates for Interior Fraser Coho Salmon. *CSAP Working Paper 2014SAL04b.*

4. Provide guidance with respect to a process to derive (or update existing) fishing-related incidental mortality rates (or range of rates) for Pacific salmon by species, gear type, location, and/or other factors deemed relevant to various fisheries (where possible and appropriate).
5. Provide guidance with respect to the future incorporation of new information and research on fishing-related incidental mortality of Pacific salmon.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Documents

Participation

- Fisheries and Oceans Canada (DFO): Science, Fisheries Management, Stock Assessment and Salmon Enhancement Program staff
- Pacific Salmon Commission Technical Committee members: Chinook, Coho, Chum, Fraser River, Northern Boundary, Transboundary representatives
- First Nations technical representatives
- Commercial and recreational fishing representatives
- Environmental non-government organizations
- Academia

References

Raby, G.D., M.R. Donaldson, S.G. Hinch, T.D. Clark, E.J. Eliason, K.M. Jeffries, K.V. Cook, A. Teffer, A. L. Bass, K.M. Miller, D.A. Patterson, A.P. Farrell, S.J. Cooke. 2015. Fishing for effective conservation: Context and biotic variation are keys to understanding the survival of Pacific salmon after catch-and-release. Int. Comp. Bio. 55(4): 554–576. doi:10.1093/icb/icv088

DFO. 2015a. Pacific Region integrated fisheries management plan, salmon, southern B.C., June 1, 2015 to May 31, 2016. (Accessed September 21, 2016.)

DFO. 2015b. Pacific Region integrated fisheries management plan, salmon, northern B.C., June 1, 2015 to May 31, 2016. (Accessed September 21, 2016.)

DFO. 2015c. Pacific region integrated fisheries management plan, salmon, transboundary rivers (Alsek, Stikine, and Taku), April 1st 2015 to March 31st 2016. (Accessed September 21, 2016.)

APPENDIX B: WORKING PAPER ABSTRACTS

CSAP WORKING PAPER 2014SAL04A: REVIEW AND EVALUATION OF FISHING-RELATED INCIDENTAL MORTALITY FOR PACIFIC SALMON

The number of fish that encounter fishing gear is greater than the number retained as catch, the proportion of this difference that die is defined as fishing related incidental mortality (FRIM). Estimates of FRIM vary across different fisheries but are required for improved stock assessments. This paper first reviews the different mortality components of FRIM (avoidance, escape, depredation, drop-out, on-board, short-term release, and delayed mortality) in relation to how a fish responds to different aspects of a fisheries encounter (e.g. fishing gear encounter, handling). To better understand how fish respond to fishing, different fishing factors that act in consort with extrinsic (e.g. water temperature) and intrinsic (e.g. fish size) factors elicit different fish responses that can lead to the different types of mortality (e.g. acute, predation) were examined. A fish response to a stressor (i.e. factor) is a combination of the magnitude and duration of the stressor itself. The initial fish response includes acute physiological stress and injury followed by behaviour changes, chronic stress, and increased infection rates. After the analysis of different factors we conducted a review process to provide an up-to-date accounting of the mortality rate information available on estimates of FRIM for Pacific salmon (*Oncorhynchus* spp.). To do so, we have created an interactive and searchable catalogue of evidence from predominantly primary literature using standardized systematic mapping protocols. Metadata information and research results from a sub-set of the studies are extracted, as well as coding information to determine study reliability and relevance. Next, we synthesize the factor and mortality information to provide recommendations on the use of five major factors that are linked to FRIM, as well as identify the major gaps in science information related to FRIM. Each one of these factors (capture time, handling (air exposure and handling time), injury, water temperature, and predators) is scaled to a mortality risk to provide guidance on evaluating both previous research and in developing FRIM estimates. The major recommendations from this work are focused on addressing the current knowledge gaps and examining FRIM in broader physiological and ecological context. Ideas for future work include researching cumulative impacts, sub-lethal effects, drop-off mortality, and predation. We have chosen a fish-centric hybrid approach that focusses first on understanding factors that drive mortality, and then on mortality estimates. As such, this paper is not meant as the definitive guide on FRIM but rather it is a transparent, defensible, and rigorous evaluation of the primary evidence base for making future decisions about FRIM rates. Future guidance on how to use the information herein is part of an accompanying CSAS research document.

CSAP WORKING PAPER 2014SAL04B: GUIDANCE TO DERIVE AND UPDATE FISHING-RELATED INCIDENTAL MORTALITY RATES FOR PACIFIC SALMON

This paper provides guidance towards deriving and updating estimates of fishing-related incidental mortality (FRIM) for Pacific salmon (*Oncorhynchus* spp.) captured in salmon-directed fisheries. We recommend condensing the multiple components of FRIM into drop-off mortality (avoidance, escape, depredation, and drop-out mortality), capture mortality (immediate or on-board mortality) and post-release mortality (short-term and delayed mortality) to assist in the practical information needs of fisheries management and stock assessment. However, for the purposes of assessing the risk of mortality, capture mortality and post-release mortality are combined into a single release mortality risk score. A risk assessment approach was designed to provide relative values of mortality risk across all major salmon-directed fisheries (i.e., various species, sectors, gears, locations). An objective process to characterize salmon fisheries in a manner that reflects their potential to cause FRIM is proposed. A procedure for generating the

overall mortality risk scores for both drop-off mortality and release mortality (capture and post-release mortality) combine the separate mortality risks associated with different levels of impact for key factors that drive FRIM, namely capture time, handling (release mortality only), injury, water temperature, and predators. The cumulative impact of the multiple factors for a given fishery is presented as a range of mortality risk scores using multiplicative, dominance, and synergistic interactions among the factors. The risk assessment tool was validated with a subset of experimental telemetry projects for which we had detailed information on the key factors and estimates of release mortality. Next, we provide advice on anchoring the relative mortality risk scores to a range of mortality estimates from FRIM studies whose purpose was to directly assess components of FRIM in a real fishery. Recommendations on sourcing and selecting the most appropriate studies to inform the risk assessment and anchoring process are provided. In addition, the major considerations in interpreting the reliability and relevance of previous FRIM research are highlighted to emphasize the potential problems inherent in selecting only a few studies. Major limitations of most FRIM research include the lack of true controls, study realism (i.e., resemblance to the real fishery), and mortality response time (e.g., immediate vs. delayed). The guidance provided on FRIM and how to estimate mortality is designed to be repeatable, transparent, and scientifically-defensible. Areas with important knowledge gaps include sub-lethal effects, cumulative impacts, understanding the role of disease, and uncertainty in scoring the relative mortality risk associated with different factors. Recommendations include the use of alternative survival analyses and the incorporation of the risk assessment process as part of a larger risk analysis plan.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon

June 6-7, 2016

Vancouver Island Conference Centre

Chair: Mary Thiess

DAY 1 – Monday, June 6

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping CSAS Overview	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper A (WP-A)	Authors
1030	***Break***	
1045	Written Reviews (WP-A)	Chair + Reviewers & Authors
1130	Identification of Key Issues for Group Discussion (WP-A)	RPR Participants
1200	***Lunch Break***	
1300	Discussion & Resolution of Technical Issues (WP-A)	RPR Participants
1445	***Break***	
1500	Presentation of Working Paper B (WP-B)	Authors
1530	Written Reviews (WP-B)	Chair + Reviewers & Authors
1645	Identification of Key Issues for Group Discussion (WP-B)	RPR Participants
1700	***Adjourn for the Day***	

DAY 2 – Tuesday, June 7

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Review Progress from Day 1	Chair
0915	Discussion & Resolution of Technical Issues (WP-B)	RPR Participants
1030	***Break***	
1045	Discussion and Resolution of Working Paper Conclusions	RPR Participants
1130	Develop Consensus on Acceptability of Papers & Agreed-upon Revisions (WP-A & WP-B)	RPR Participants
1200	***Lunch Break***	
1300	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Sources of Uncertainty • Results & Conclusions • Additional advice to Management (as warranted)	RPR Participants
1430	***Break***	
1445	*Science Advisory Report (SAR)* (Continued)	RPR Participants
1630	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines • Other follow-up or commitments (*as necessary)*	Chair
1645	Other business arising from the review	Chair & RPR Participants
1700	***Adjourn meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Ashton	Chris	Commercial Salmon Advisory Board (CSAB)
Brown	Gayle	DFO Science
Campbell	Kelsey	A-Tlegay Fisheries Society
Chauvel	Dane	Commercial Salmon Advisory Board
Conrad	Bob	Fraser River Technical Committee (US)
Cook	Katrina	University of British Columbia (UBC), Author
Cooke	Steve	Carleton University, Author
Cox-Rogers	Steve	DFO Science
Crowley	Sabrina	Pacific Salmon Commission
Cue	Chris	CSAB/Pacific Salmon Commission (PSC)-Northern Panel
Dedeluk	Nic	Namgis First Nation
Farrell	Tony	UBC, Reviewer
Flostrand	Linnea	DFO Science
Gale	Rupert	Sport Fishing Advisory Board (SFAB)-Monitoring & Compliance Panel
Gillespie	Aaron	Secwepemc Fisheries Commission
Gotch	Steve	DFO Science
Gottesfeld	Allan	Skeena Fisheries Commission
Grout	Jeff	DFO Fisheries Management
Hamilton	Shelee	DFO Science, Rapporteur
Haugan	Rick	CSAB-Seine/Area A Harvest Committee
Hawkshaw	Mike	DFO Fisheries Management
Hinch	Scott	UBC, Author
Hope	Dominic	Yale First Nation
Houtman	Rob	DFO Science
Huang	Ann-Marie	DFO Science
Jantz	Les	DFO Science
Kristianson	Gerry	Sport Fishing Advisory Board
Laliberte	Bernette	Cowichan Tribes
Lemieux	Jeffrey	DFO Science
Macdonald	Steve	DFO Science, Reviewer
MacDougall	Lesley	DFO Science - CSAP Office
Mariscak	Ann	DFO Science - CSAP Office
Maxwell	Marla	DFO Fisheries Management
McGrath	Elinor	Okanagan Nation Alliance/PSC CTC
Morishima	Gary	Quinault Nation/Pacific Salmon Commission SFEC TC
Nettles	Taylor	UBC, Author

Last Name	First Name	Affiliation
Nicklin	Pete	Fraser River Aboriginal Fisheries Secretariat/PSC Coho TC
Ormond	Chad	Q'ul-lhanumutsun Aquatic Resources Society (QARS)
Paish	Martin	Sport Fishing Advisory Board
Parken	Chuck	DFO Science
Patterson	David	DFO Science
Payne	Brigid	DFO Fisheries Management
Potyrala	Mark	DFO Science
Raby	Graham	University of Windsor
Rankis	Andy	Suquamish Tribe
Ritchie	Lynda	DFO Science
Robinson	Kendra	DFO Science
Rosenberger	Andy	Raincoast Conservation Foundation
Sawada	Joel	DFO Science
Schut	Steven	DFO Science, Rapporteur
Scroggie	Jamie	DFO Fisheries Management
Silvey	Ray	Island Marine Aquatic Working Group
Staley	Mike	Fraser River Aboriginal Fisheries Secretariat
Thiess	Mary	DFO Science, Chair
Thorkelson	Joy	Area C Harvest Committee
Tompkins	Arlene	DFO Science
Van Will	Pieter	DFO Science

APPENDIX E: WORKING PAPER REVIEWS

REVIEWER: TONY FARRELL, UBC

CSAS Working Paper 2014SAL04a
Working Paper Title: Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon

Objectives research document A

1. Identify and discuss potential impacts of key factors that can influence fishing-related incidental mortality for Pacific salmon.

   Addressed extremely well

2. Conduct a comprehensive review of the primary and grey literature that contains documented evidence (e.g. mortality rates) of fishing-related incidental mortality for anadromous salmonids.

   Good, but not complete coverage of literature. Some sections poorly written though.

3. Identify uncertainties and knowledge gaps in the information that is currently available to inform estimates of fishing-related incidental mortality for Pacific salmon.

   Uncertainties identified but unclear how these were integrated into the final %mortality estimates is unclear.

Objectives research document B

1. Provide guidance with respect to a process to derive (or update existing) fishing-related incidental mortality rates (or range of rates) for Pacific salmon by species, gear type, location, and/or other factors deemed relevant to various fisheries (where possible and appropriate).

   The basic process is good but ALL the linkages in the process are not necessarily clear.

2. Provide guidance with respect to the future incorporation of new information and research on fishing- related incidental mortality of Pacific salmon.

   The consolidation of the practices will not aid application of the new information into a more effective practice.

   The lack of transparency in how expert input was used in deriving the %mortality will not help downstream acceptance.

Specific answers to your Questions

- Is the purpose of the working paper clearly stated and aligned to the Terms of Reference for this CSAS Review?

  Yes

- Are the data and methods adequate to support the conclusions?

  No, there is one critical linkage that has not been explained and documented.

- Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

One critical aspect is vague

- If the document presents advice to decision-makers, is the advice and/or recommendations aligned to the objectives in Terms of Reference and in a useable form.

Partially

- Does the advice reflect the uncertainty in the data, analysis or process?

Unclear

- Are there additional areas of research that are needed to improve the quality of or the ability to provide advice and recommendations related to the stated objectives?

Improved presentation

A new consideration that separates risk of mortality from the likelihood of a particular practice in fisheries.

General comments

My expectation of this CSAS document is that it would improve management of wild fisheries management by improving mortality estimates (FRIM) with the introduction of a new framework that better acknowledges existing knowledge. My hope is that it would lead, as well, to improved fishing practices by identifying risks that could be mitigated with relative ease. This will require that the present document dovetails seamlessly with the existing framework and that the authors can easily defend their %mortality estimates to fishery practitioners.

The documents unquestionably provide a solid, sound and well-explained framework to assess FRIM. The text, figures and tables do a good job of definitions and distinctions. Missing is an easy way for a reader find definitions of all the complex and confusing terminology used with fishing practices and FRIM. This problem can be resolved easily by expanding the Glossary to a 'quick reference guide for terms and abbreviations' and locating it at the front of the document. A linkage to DFO's 1-5 ranking of fish condition in by-catch is also needed.

Document B is easy to read and follow. However, I have overriding concerns with how Risk (= possibility of loss or injury) was assigned in Document A and this will affect summary statements made in Document B. While I understand that a particular practice will result in a risk of mortality, it seems to me that the likelihood of that practice being used in fisheries is not evaluated at all. For example, if a fish is held out of the water for 6 h before being returned, I have no problem with assigning a risk of mortality of 45-100%. However, the likelihood (=probability) of a fish being held out of water for this long a period without being returned is extremely low. It is this aspect of likelihood that is missed.

More critical is a transparency to how the literature and 'expert knowledge', were combined to generate the risk percentages. As I see it, the document does a better job of showing that expert knowledge is NOT good at estimating FRIM, as evidenced in the validation graphs where the 'experts' overestimate low mortality and underestimate high mortality. Given these data and the repeated observation that there was insufficient literature for various factors of concern, I need to be better convinced that the authors can resolve FRIM to a 5% level, which some of their categories suggest.

One recommendation is to focus on survival rather than mortality. While I understand why this might be so, it seems out of place. Foremost the authors largely talk about mortality in the report, and conclude with mortality in their tables. Secondly, if there is no reliable estimate of population size, how can you talk about survival?

Unlike Document B, Document A is far from a mature report and reads more like an unedited work in progress. I can't say Document A was an easy or enjoyable read. The first part of the document is in reasonable shape. The new framework is well-developed in Section 1, the figures and tables help enormously when the text gets complex. Most of all the fish-centric view is both sound and sensible. In contrast, the literature review is problematic – sections 2 and 3 tend to blur in their coverage of the literature. As a whole, these two sections tended to be very wordy and less than direct in both big and small ways, sometimes with loose statements that bordered on misleading. Some sections seem to have lacked adequate expertise and other section could reduced in length or deleted entirely.

Some random examples (there are many to choose from):

Misleading sentence construction: "Pacific salmon can be eaten by birds, bears, wolves and marine mammals in fresh water". "did not find any effect of sex on discard mortality"

Need for better focus/expertise: The intro to section 2.8.4. Adult salmon are maturing and not feeding while they move from seawater to freshwater. Therefore, relevant literature, by necessity, has to be focused and restricted. Consequently, literature on lobster is totally irrelevant – they are isotonic with seawater and can withstand long periods of aerial exposure.

Wordiness/vague: "If an individual fish is in a physiologically compromised state (e.g., heightened stress or strain on the immune system, cardiorespiratory system, or endocrine system) prior to the capture event, the individual may have a lower likelihood of survival during capture or post- release. In any study of fisheries-induced mortality there is unexplained variation whereby two apparently similar fish are exposed to a seemingly identical fisheries interaction and yet one suffers delayed post-release mortality while the other survives." "Overall, the volume of evidence and the strength of evidence for pre-existing injury or infection playing a role in FRIM for Pacific salmon is low, and primarily limited to indirect studies and anecdotal evidence. Nevertheless,..."

Document A also describes how relevant literature was surveyed. Some key pieces of relevant literature known to the reviewer were omitted, raising into question the general search process. E.g, I am sure that Ian Birtwell produced a number of DFO reports on the effects of sediment on salmon that are not included in 2.8.3.

Furthermore, from the following quote, it suggests to me that the literature review and hence the report was incomplete (and suggests that DFO-based reports are possibly less important than primary literature – I disagree). "To increase transparency and repeatability we prioritized the extraction of information from primary literature articles from the Web of Science search. This is an iterative process and future work will extract data from articles identified by the WAVES search and additional sources (Figure 6)." I do not see how this bias "increases transparency and repeatability" either.

There was also an unbalanced reviewing of literature. There may have been a bias towards literature since ~2000. E.g., pioneer works of E. Black that are not in the literature review but relevant. Such bias can be explained only in part by an increase in relevant research. Also, details of the literature were definitely greater for the literature that was most close to the authors. Some important literature was skimped or not properly covered. Lastly, the literature review appears to be take 'reviews' at face value without consulting the primary findings to validate the reporting in the review was accurate.

Perhaps there is a need to condense Section 2 and move some of the literature review to Section 3.

Where I had most trouble was the leap from the literature view with an interposing of undisclosed and documented 'expert opinions' that mysteriously brought us to the summaries presented in Table 4.1.2.1 et seq, which is the pivotal output of the entire document.

REVIEWER: ALEX WERTHEIMER, FISHERIES RESEARCH BIOLOGIST (RETIRED) - U.S. NATIONAL MARINE FISHERIES SERVICE

CSAS Working Paper 2014SAL04a
Working Paper Title: Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon

Is the purpose of the working paper clearly stated and aligned to the Terms of Reference for this CSAS Review?

The authors state the objectives as defined by the Terms of Reference. They also describe their approach, which is to address these objectives in two parts. This document represents Part A, and covers three of five major objectives: identifying factors associated with fishing-related incidental mortality (FRIM) for Pacific salmon; providing a comprehensive review of FRIM estimates; and identifying uncertainties and knowledge gaps. As such, it represents a precursor to the major goal of the overall working paper: to provide recommendations on a process to derive and/or modify current estimates of fisheries-related incidental mortality rates for use in the assessment and management of Pacific salmon fisheries. This goal is encapsulated in objectives 4 and 5, which will be the subject of Part B.

Are the data and methods adequate to support the conclusions?

The authors approach is an extensive review of peer-reviewed and grey literature to develop information sets relating to factors affecting mortality and to review FRIM mortality rates. They summarize the factor review and evaluate their relative importance in affecting FRIM. Both sources of information, factors and mortality estimates, are then used to identify key factors and develop "factor mortality risk scores" that can potentially be used for describing and predicting FRIM. Finally, the authors identify uncertainties and knowledge gaps in the estimation of FRIM, based on their reviews and evaluations. The authors have done an impressive job of providing comprehensive literature reviews, and have used both the information generated and their expert opinions to validate their risk scores. They should note that application of these risk scores must explicitly consider interactions among factors, and may require a prioritization of factors, when applied to a specific fishery or even an individual observation. For example, both capture time and handling time may be short for a coho salmon caught in a commercial troll fishery, but if the hook has caused a broken gill arch, mortality will be high. When multiple risk factors are known, the authors should explain how they can be integrated to provide an overall prediction of FRIM.

Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

The intellectual approach and the methodology are very well documented and explained. The section on Factors was quite detailed, with specific references to support the identification and quantification (or lack thereof) of factors affecting FRIM. I would have liked to see more summarization of the actual mortality estimates from the studies identified in Section 3. For example, what are the range of estimates observed or estimated in these studies by species and gear types? What are the ranges of estimates for drop-off, immediate, short-term, and long term FRIM? The authors have used this information in developing their risk matrixes in Section 4, and it is of high interest of a manager concerned with FRIM. I thought perhaps they had deferred this type of summary to Part B, but I did not find it in that document either.

If the document presents advice to decision-makers, is the advice and/or recommendations aligned to the objectives in Terms of Reference and in a useable form.

This document is the precursor to direct advice or recommendations to managers on FRIM. The tools they have developed should help provide insight to managers in assessing the mortality of fish that have encountered fishing gear and then been released or escaped under a range of environmental conditions. They are very clear that FRIM is only one component of the information needed to effectively manage salmon populations. They could also perhaps be a bit clearer that the mortality, that is the probability that a fish dies from the gear encounter, is also only one component of FRIM. This is the aspect of FRIM on which their "fish-centric" approach focuses. They note in the introduction that encounter rates are beyond the scope of the document. However, it would be useful to managers to have some information on the sensitivity of estimates FRIM to the range of uncertainty in encounter rates versus that of the probability that a fish dies from the encounter.

Does the advice reflect the uncertainty in the data, analysis or process?

The authors have been very clear in identifying the large uncertainties in terms of the existing data, the numerous knowledge gaps, and the inherent difficulties in studying the lethal and sub-lethal outcomes of an encounter and then release or escape from fishing gear. As stated above, they also point out that FRIM is only one component of the information needed to effectively manage salmon populations.

Are there additional areas of research that are needed to improve the quality of or the ability to provide advice and recommendations related to the stated objectives?

The authors have done an excellent job at identifying data gaps and recommending research needs to improve the understanding of factors affecting FRIM and the estimation of FRIM in specific fisheries. I am in complete agreement with the top three items on their recommendation list: drop-off mortality, the implications of multiple encounters, and the quantification of marine mammal predation in contributing to FRIM. I would add to their list the need for accurate estimates of encounter rates. In the computation of FRIM, either catch rates or total encounter rates are used to estimate drop-off mortality. Estimates of mortality of fish caught and released is based on the estimated probability of death times the encounter rates. Encounter rates CAN be estimated with accuracy and precision using observer programs, validated log books, and video recording devices. Accurate estimation of encounters of non-target species/sizes can thus provide much improved estimates of FRIM and can also potentially lead to research or management actions towards reducing such encounters.

Additional Comments

- **Section 2.6.1.6:** Note that statement in reference to Hühn and Arlinghaus (2011) is reversed, lures have lower mortality than bait.
- **Section 2.6.1.7:** Orsi et al. (1993), which is cited elsewhere, should be included in reference to circle hooks. Also, the paper by Grover et al. (2002), listed as "unobtainable", should be referenced with the circle hook (and wound location) discussion. This paper should be available from the American Fisheries Society.
- **Section 2.7.1.** A paper that was not included in the references, Vincent-Lang et al. (1993: Mortality of coho salmon using sport tackle in the Little Susitna River, Alaska. Alaska Fisheries Research 15: 339-356.), should be referenced in this section. It shows mortality following catch-and-release on recreational fishing gear was much higher for coho salmon captured in an estuary than those captured in freshwater, indicating that the fish are more sensitive to the stress of capture when undergoing the transition from saline to fresh water.

REVIEWER: STEVE MACDONALD, DFO SCIENCE - PACIFIC

CSAS Working Paper: 2014SAL04b
Working Paper Title: Guidance to Derive and Update Fishing-Related Incidental Rates for Pacific Salmon

General Comments

a) **Is the purpose of the paper aligned with the ToR:** Yes, it is an ambitious attempt to address an important component of salmonid fisheries management where little experimental data exists.

b) **Are the data adequate and supportive:** Interesting question because the premise of the document is to make educated estimates on an important issue where many data gaps exist. There is a role for expert opinion in these situations as a means to generate useable data but this is a sophisticated field (i.e. Decision Support Modelling) in which I am probably not qualified to advise or review. As written Table 4 suggests that the approach cannot be validated with the data but this was based on only 12 case studies with a limited number of species in a single system (see also comment 3d). Perhaps the authors could use expert advice to parameterize a model based on the conceptualized diagram in Figure 2 (see also comments 3a)? At this stage the data does support the conclusions but with many gaps and sources of uncertainty that may lead to controversy and acrimony. It is a magnificent effort that should not be lost but its immediate operationalization needs to be debated.

c) **Are the data and methods described sufficiently:** Yes, there is an impressive collection of literature perhaps "exhaustive" in its coverage and the methods are well described although I have suggested a few places where explanations are lacking or unclear (e.g. 3b, a and d). Res Doc A must be read in order to make sense of Res Doc B and I found it dense and long and therefore difficult to absorb with the time I was able to allot for the review. Some of my detailed comments properly belong to the review of Res Doc. A (i.e. 3b, a to d).

d) **The document does provide advice to decision-makers that is aligned with the objectives in the TOR:** But I am not sure that enough certainty exists (too many data gaps) to actually use this document to estimate a FRIM for the purposes of managing fisheries (see also 3b,c). Perhaps this is a decision to be made upon reflection of all of the reviews and discussions at the CSAS meeting.

e) **Does the advice reflect the uncertainty in the data and analysis:** The authors are well aware of the degree of uncertainty inherent in their proposal and take steps to address it. However, I think much more work is required before an unbiased error can be expressed with this method.

The authors are aware of these problems and have made the best possible attempt to describe error with their validation method (which is itself biased)(see also 3d).

f) **Are there additional areas of research that are needed for improvement...:** Yes and they are many. But perhaps the strongest contributions from these research documents are the identification of the sources of mortality (i.e. subjects for future research) and the many data gaps and intractable research issues that prevent a direct estimate of FRIM.

Minor Comments (editorial in nature, not required content for the review meeting):

a) P.2, line 9 – do you mean "introspective" or retrospective? I suppose the experimental approach being described may be inward looking but a real limitation of the approach is that it reveals information retrospectively and is therefore of limited value for prediction.

b) P.2, para 3 – the first line seems out of place. Why the reference to natural mortality to start a paragraph concerned with FRIM?

c) P.9, line 4 – I agree for the need for table 2 to provide relevant descriptors necessary to link to fish mortality, the success of the risk assessment depends on it but I suggest that it's a bit bold to imply that these descriptors are sufficient to accurately predict the factors that influence mortality in all situations. Line 15 states that date and location will be sufficient to predict water temperature. This is unlikely true in all situations and all fisheries. Furthermore, based on our imperfect understanding of the influence of temperature on captured fish (Res Doc A, p.62) our estimate of its effect during capture is perhaps no better than an educated guess. Finally, all of the impact levels of the relevant factors are subject to an uncertainty that is associated with the means it was estimated and will contribute to an accumulating error in the final risk estimate. What influence will this have on the final estimate of mortality?

d) Table 2, caption, line 2 – add a "the" as in "elements of the fishery".

e) P.11, 3rd para, line 1 - The use of "regardless" throws me off. Why does a general factor apply regardless of environmental condition (line 2) when one of the factors is an environmental condition (water temperature – line 4).

f) Res Doc. A, p.67, third Para, last line – check for an unnecessary "f".

g) Appendix A – some of the tables have line wrap issues (at least on my printer). Similarly for the same tables in Res Doc A.

Major Comments (more appropriate for discussion during the review meeting):

a) P. 5, para. 1 – Figure 2 is a good conceptualization of a PoE Model (Pathways of Effects) that describes all of the components where knowledge is required to estimate FRIM. As it is written it describes the complexity of the problem and advises future research direction. However, I question why the authors would then reduce these largely independent factors into three mortality rates (and later two, p.7-8) rather than retain all seven through the modelling process. The NCM in particular captures four sources of mortality that are likely to vary widely depending on species, fishing location etc. The authors provide a good explanation why these sources of mortality are different from the rest (assessment against all fish influenced by the fishery with an intent to retain of not) but the only reasons given for the NCM combination are: a) seven component estimates would be complicated (p. 5, line 4) and, b) the challenge to develop reliable estimates for each. I may be missing the point of the exercise and I'm sure the authors have debated this issue during the development of the documents but I don't think either of the reasons above are sufficient. Firstly, it is a complicated issue and a complicated process to reach a solution is expected. Secondly, the ToR for this CSAS refers to the incorporation in the future of new information. I suggest that the construction of a complicated model that captures all mortality processes is more realistic, directs future research and may accept new information without modification and further review processes (such as this CSAS). Besides it could possibly lead to improved estimates (p.6, 2nd paragraph, line 6). I'd like to hear this debated during the meeting).

b) P.11, 6th para. – Fundamental to the improving FRIM estimates following the guidance provided in Res Doc B is the acceptance of the advice of experts to accurately estimate a

score for each of the factors. I won't quibble with the choice of factors (I did that previously, see a), nor will I question the choice of experts except to say I hope they have published in this field rather than simply reviewed the impressive mass of material from Res Doc A. But there are few details on the process used to arrive at the scores and most is in Res Doc A, the review of which is critical to the validity of the guidance in Res Doc B. Here then a few comments that may apply more to Res Doc A:

a. The experts were involved in the selection of the 5 factors (Res Doc A p.67-69) but were they then asked to scale the factors? I admit to a limited knowledge of quantification of expert advice but I understand that process to pose questions to experts during the development of Decision Support Systems is a formal method of asking the question and an active effort to avoid a conflict between those that develop the questions and those that provide the answers. I think the approach used needs to be spelled out in Res Doc B and I suggest a review occur by an expert in the field of Decision Support.

b. It would appear (p.67-69) that the factors chosen were those with few "limitations" (bottom p.69). I would like to examine these limitations based on the concern that it is not the biological processes (so well portrayed in Res Doc B-Fig.2) driving the mortality factors but the ease of measurement, amount of evidence etc. I do admit that the authors properly consider the "Mechanism for Action" (p.67) which does address my concern. However, there must be many sources of stress that are difficult to estimate, poorly understood, infrequently studied with inconsistent results that are important and whose absence could bias the estimates.

c. An obvious issue that the authors are well aware of is the bias in both publications and experts towards specific fisheries (recreational – bottom p.72) and specific species (Table 6) requiring inferences in the factor scaling (top p. 73). I can't be too critical because both documents do an excellent job of identifying knowledge gaps (e.g. p. 80-82) and successfully "document the problem" (p. 82 last para.) but with all this uncertainty and insufficient knowledge are we really ready to use a risk assessment approach to modify estimates of mortality rates?

d. The choice of numbers of bins, bin size range and their asymmetry is supported with reference to greater uncertainty at extreme stress and the ubiquity of "threshold type" responses among stressors (p. 73, para 6 and Res Doc B, p.11-12). This deserves debate. Considering the potential for sub-lethal and cumulative effects of stress, would the less severe influences not be less certain than an effect near a threshold. And if these stressors act as thresholds why have 6 categories – the assessment becomes binary, above or below?

c) The discussion of Cumulative Impacts and their application to the Tabulation of Risk (p.12-13) is interesting and applicable to the process. But it poses several issues. I have heard stressors referred to as being cumulative (Williams, Fagerlund etc. from the 1980's and 90's) and this entire CSAS process is about the combined effect of different sources of stress. I would expect "Dominance" be used when risk of mortality was high and the interaction of stressors was immaterial – i.e) at least one of them alone will cause mortality. But the authors suggest that this measure of interaction will generate the lowest rate of mortality because the additive or multiplicative effects of stress are ignored – is this realistic? The multiplicative treatment of interaction makes sense to me for most stressors for the reasons stated above. However, by definition, stressors that act at thresholds could possibly act synergistically – neither alone causes mortality but together they may. Regardless I'm surprised that synergistic interactions were discounted by Cote et al. (p.13, 1st para.).

d) The attempt to validate the expert-derived risk of mortality with observations from 12 pilot studies was inventive and interesting (p. 15-16). The correlation among ranks (Figure 3) were promising but I challenge the statement on the first line on p. 17 that suggests the purpose of the guidance in Res Doc B. is to "generate relative mortality risk .... for comparison to other fisheries". I don't see a lot of regulatory value to derived *relative* estimates and refer the audience to page 1 where this document proposes guidance for species/location/gear-type- specific FRIM's. It is therefore the correlation described in Figure 4 that is most interesting and it suggests that as interpreted the mortality risk scores are not good estimates of mortality rates (p. 15 2nd para.). I agree with the authors that this is an opportunity for further work to test assumptions – is some reverse engineering possible to improve the approach to extracting the expert's advice or the range and values within the bins?